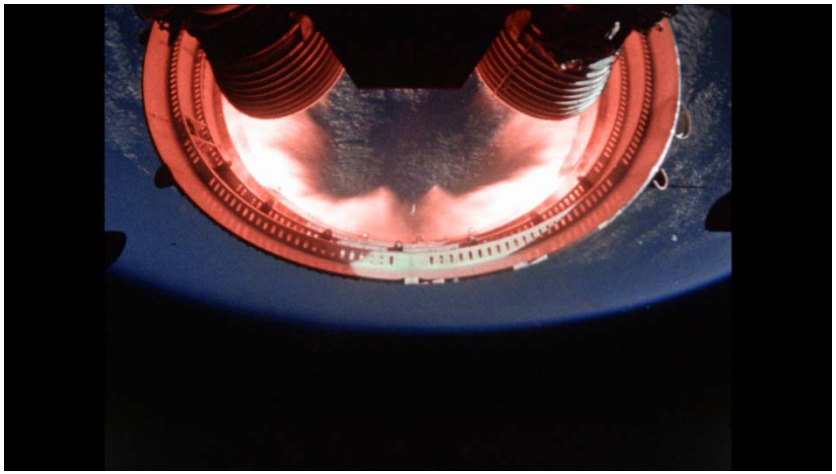
Digital Video over Space Systems & Networks

SpaceOps 2010

Rodney Grubbs
NASA MSFC
256-544-4582
Rodney.Grubbs@nasa.gov

Introduction

- Space imagery started with film
  - Public saw the footage after the mission
  - Black & White and Color motion picture film
  - Slow frame rates
  - Had to get the film back!
- Live TV from space!
  - Black & White
  - Color via Black & White “color wheel” system
  - Long term ground recording via film kinescopes
  - Lots of unique video
    - Field sequential
    - ISS VBSP



Digital Video Parameters

- Analog video pretty simple
  - PAL, SECAM and NTSC
  - Interlace, frame rates and resolution differences
- Digital Video a bit more complicated
  - Horizontal/Vertical resolution options
    - 480, 720 and 1080
  - Scanning
    - Interlace
    - Progressive
  - Frame Rates
    - You name it
  - Aspect Ratios
    - 4:3
    - 16:9
    - 14:9
  - Color Sampling
    - 4:2:0
    - 4:2:2
    - And a bunch of other schemes

Video over IP

- Digital Video requires a lot of compression
  - SDTV is 270 Mbps uncompressed
  - HDTV is 1.485 Gbps uncompressed
  - MPEG-2
    - Groups of pictures
      - I, B and P frames
    - Frames divided into 8 x 8 pixel blocks
  - MPEG-4
    - MPEG-4 Part 10 = h.264
    - Compression between blocks and frames
  - Motion JPEG2000
    - Intraframe compression

Video over IP

- Transport Stream
  - Combines video, audio and other elements together
  - Typically used for real-time video applications such as terrestrial broadcasting or digital video satellite systems
  - Advantages
    - Video & audio in sync
    - Common hardware solutions for encoding and decoding
    - Easy IP routing or video routing (using Asynchronous Serial Interface)
  - Dis-Advantages
    - Added bandwidth overhead
      - Packetization stacks are common
    - Susceptible to packet-loss and jitter

Video over IP

- Program Element Stream
  - Video and audio are separate
  - Typically used for file-based playback, such as with DVD, or from computers
  - Advantages
    - Computer to computer friendly
    - Flexibility with audio and video
    - Less bandwidth overhead
  - Dis-Advantages
    - Re-synchronization of audio and video
    - Hard to take out of the IP world and into the video world (ASI)

Video over IP

- Real-time Transport Protocol
  - Typically used for end-to-end multimedia applications like voice-over-IP or video teleconferencing
  - More tolerant of packet drops and jitter, but…
  - ….that requires end-to-end bi-directional links, or “handshakes”….
  - …which makes use of RTP for space links challenging
  - Also, most commercial decoders cannot recognize RTP streams
  - Best when used entirely within the computer domain, not a good candidate for use between computers and conventional video equipment

Link Integrity

- Encoded video creates a high bandwidth synchronous data stream, susceptible to packet loss and network jitter
- Video is typically the largest data requirement for a spacecraft avionics system compared to telemetry, voice and other data streams
- Therefore, video drives the link integrity requirements
- MPEG-4 more susceptible to bit errors, packet loss and jitter problems than MPEG-2
- Motion JPEG-2000 less susceptible because there is no interframe encoding

Latency

- Compression creates latency
- Packetization of the data stream adds to that latency since the stream has to be de-packetized on the ground to get back to a signal that can be decoded
- Typically, the better the video quality, the longer the latency, since the encoder takes more time to analyze the incoming video for quality enhancement
- Real-time monitoring on spacecraft and the ground need to consider the latency vs. quality trade-off
  - Rendezvous
  - Interactive conversations
  - Time, voice and metadata synchronization with video

Conclusion

- Digital video provides many improvements but comes with new challenges
- Video as data allows for improved workflows and reusing data systems and avionics for routing of video
- Designers and System Engineers must consider impacts of compression, Video-over-IP options & trades, link integrity and latency on their video system
- End-to-end System Engineering is key!
  - Can’t treat digital video piece-meal and expect good results
  - The payoff can be some incredible imagery, useful for science, engineering, control center monitoring, and engaging the public